

PATENT COOPERATION TREATY

From the INTERNATIONAL SEARCHING AUTHORITY

PCT

NOTIFICATION OF TRANSMITTAL OF
THE INTERNATIONAL SEARCH REPORT
OR THE DECLARATION

(PCT Rule 44.1)

To:
LADAS & PARRY
Attn. GALLOWAY, Peter D.
26 West 61st Street
NEW YORK, NY 10023-7604
UNITED STATES OF AMERICA

28 Rec'd PCT/PTO 08 APR 1998

Date of mailing (day/month/year)	07/04/1998
-------------------------------------	------------

Applicant's or agent's file reference
119,387

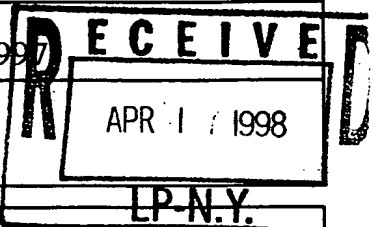
FOR FURTHER ACTION See paragraphs 1 and 4 below

International application No.
PCT/US 97/ 15844

International filing date (day/month/year)	02/10/1997
---	------------

Applicant

CARGILL INCORPORATED et al.



1. ☒ The applicant is hereby notified that the International Search Report has been established and is transmitted herewith.

Filing of amendments and statement under Article 19

The applicant is entitled, if he so wishes, to amend the claims of the International Application (see Rule 46):

When? The time limit for filing such amendments is normally 2 months from the date of transmittal of the International Search Report; however, for more details, see the notes on the accompanying sheet.

Where? Directly to the International Bureau of WIPO
34, chemin des Colombettes
1211 Geneva 20, Switzerland
Facsimile No.: (41-22) 740.14.35

For more detailed instructions, see the notes on the accompanying sheet.

2. ☐ The applicant is hereby notified that no International Search Report will be established and that the declaration under Article 17(2)(a) to that effect is transmitted herewith.

3. ☐ With regard to the protest against payment of (an) additional fee(s) under Rule 40.2, the applicant is notified that:

☐ the protest together with the decision thereon has been transmitted to the International Bureau together with the applicants's request to forward the texts of both the protest and the decision thereon to the designated Offices.

☐ no decision has been made yet on the protest; the applicant will be notified as soon as a decision is made.

4. **Further action(s):** The applicant is reminded of the following:

Shortly after 18 months from the priority date, the international application will be published by the International Bureau. If the applicant wishes to avoid or postpone publication, a notice of withdrawal of the international application, or of the priority claim, must reach the International Bureau as provided in Rules 90bis.1 and 90bis.3, respectively, before the completion of the technical preparations for international publication.

Within 19 months from the priority date, a demand for international preliminary examination must be filed if the applicant wishes to postpone the entry into the national phase until 30 months from the priority date (in some Offices even later).

Within 20 months from the priority date, the applicant must perform the prescribed acts for entry into the national phase before all designated Offices which have not been elected in the demand or in a later election within 19 months from the priority date or could not be elected because they are not bound by Chapter II.

Name and mailing address of the International Searching Authority
European Patent Office, P.B. 5818 Patentlaan 2
NL-2280 HV Rijswijk
Tel. (+31-70) 340-2040, Tx. 31 651 epo nl,
Fax: (+31-70) 340-3016

Authorized officer

Michael Davidson

ENTERED BY
CENTRAL
ACTION

ENTRY

EXTERM

08-04-98

PCT

INTERNATIONAL SEARCH REPORT

(PCT Article 18 and Rules 43 and 44)

Applicant's or agent's file reference 119,387	FOR FURTHER ACTION see Notification of Transmittal of International Search Report (Form PCT/ISA/220) as well as, where applicable, item 5 below.	
International application No. PCT/US 97/ 15844	International filing date (day/month/year) 02/10/1997	(Earliest) Priority Date (day/month/year) 09/10/1996
Applicant CARGILL INCORPORATED et al.		

This International Search Report has been prepared by this International Searching Authority and is transmitted to the applicant according to Article 18. A copy is being transmitted to the International Bureau.

This International Search Report consists of a total of 3 sheets.

☒ It is also accompanied by a copy of each prior art document cited in this report.

1. ☐ Certain claims were found unsearchable (see Box I).

2. ☐ Unity of invention is lacking (see Box II).

3. ☐ The international application contains disclosure of a **nucleotide and/or amino acid sequence listing** and the international search was carried out on the basis of the sequence listing

☐ filed with the international application.

☐ furnished by the applicant separately from the international application,

☐ but not accompanied by a statement to the effect that it did not include matter going beyond the disclosure in the international application as filed.

☐ Transcribed by this Authority

4. With regard to the **title**, ☐ the text is approved as submitted by the applicant

☒ the text has been established by this Authority to read as follows:

PROCESS FOR THE RECOVERY OF LACTIC ACID BY CONTACTING AQUEOUS SOLUTIONS CONTAINING THE SAME WITH A BASIC ORGANIC EXTRACTANT

5. With regard to the **abstract**,

☒ the text is approved as submitted by the applicant

☐ the text has been established, according to Rule 38.2(b), by this Authority as it appears in Box III. The applicant may, within one month from the date of mailing of this International Search Report, submit comments to this Authority.

6. The figure of the **drawings** to be published with the abstract is:

Figure No. — ☐ as suggested by the applicant.

☐ None of the figures.

☐ because the applicant failed to suggest a figure.

☐ because this figure better characterizes the invention.

INTERNATIONAL SEARCH REPORT

International Application No.

PCT/US 97/15844

A. CLASSIFICATION OF SUBJECT MATTER

IPC 6. C07C51/47 C07C51/48

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

IPC 6 C07C

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practical, search terms used)

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category *	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	US 5 510 526 A (BANIEL ABRAHAM M ET AL) 23 April 1996 cited in the application see column 3, line 10 - column 4, line 10 see column 4, line 25 - column 5, line 6 see column 9, line 39 - line 60 see example 1 ---	1,13, 15-17,20
X	US 5 132 456 A (KING C JUDSON ET AL) 21 July 1992 cited in the application see column 1, line 26 - line 41 see column 3, line 63 - column 4, line 21 see column 13, line 58 - column 14, line 51 see examples 1-8,12-14 see claims 1-13 --- -/--	1,13,16, 17

☒ Further documents are listed in the continuation of box C.☒ Patent family members are listed in annex.

* Special categories of cited documents:

"A" document defining the general state of the art which is not considered to be of particular relevance

"E" earlier document but published on or after the international filing date

"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)

"O" document referring to an oral disclosure, use, exhibition or other means

"P" document published prior to the international filing date but later than the priority date claimed

"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone

"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art.

"&" document member of the same patent family

Date of the actual completion of the international search

17 March 1998

Date of mailing of the international search report

07/04/1998

Name and mailing address of the ISA

European Patent Office, P.B. 5818 Patentlaan 2
NL - 2280 HV Rijswijk
Tel. (+31-70) 340-2040, Tx. 31 651 epo nl,
Fax: (+31-70) 340-3016

Authorized officer

Held, P

INTERNATIONAL SEARCH REPORT

International Application No
PCT/US 97/15844

C.(Continuation) DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	<p>WO 95 25081 A (YISSUM RES DEV CO ; WHALLEY KEVIN (GB); EYAL AHARON MEIR (IL)) 21 September 1995 see page 1, line 3 - line 10 see page 9 see page 11 see page 13 see claims 1-20</p> <p>----</p>	1-23
A	<p>US 4 882 277 A (CZYTKO MICHAEL ET AL) 21 November 1989 see column 2, line 25 - column 3, line 2 see claims 1-8</p> <p>-----</p>	23

INTERNATIONAL SEARCH REPORT

Information on patent family members

International Application No

PCT/US 97/15844

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
US 5510526 A	23-04-96	AU 7179494 A BR 9408558 A CA 2184928 A EP 0804607 A WO 9524496 A	25-09-95 19-08-97 14-09-95 05-11-97 14-09-95
US 5132456 A	21-07-92	NONE	
WO 9525081 A	21-09-95	AU 1858295 A CA 2185575 A EP 0750603 A	03-10-95 21-09-95 02-01-97
US 4882277 A	21-11-89	JP 62146595 A CA 1295963 A EP 0230021 A	30-06-87 18-02-92 29-07-87

PATENT COOPERATION TREATY

From the INTERNATIONAL BUREAU

PCT

NOTIFICATION OF ELECTION

(PCT Rule 61.2)

To:

United States Patent and Trademark
Office
(Box PCT)
Crystal Plaza 2
Washington, DC 20231
ETATS-UNIS D'AMERIQUE

in its capacity as elected Office

Date of mailing (day/month/year)

25 May 1998 (25.05.98)

International application No.

PCT/US97/15844

Applicant's or agent's file reference

119,387

International filing date (day/month/year)

02 October 1997 (02.10.97)

Priority date (day/month/year)

09 October 1996 (09.10.96)

Applicant

EYAL, Aharon, Meir et al

1. The designated Office is hereby notified of its election made:



in the demand filed with the International Preliminary Examining Authority on:

07 May 1998 (07.05.98)



in a notice effecting later election filed with the International Bureau on:

2. The election ☒ was

was not

made before the expiration of 19 months from the priority date or, where Rule 32 applies, within the time limit under Rule 32.2(b).

The International Bureau of WIPO
34, chemin des Colombettes
1211 Geneva 20, Switzerland

Facsimile No.: (41-22) 740.14.35

Authorized officer

I. Britel

Telephone No.: (41-22) 338.83.38

PCT

WORLD INTELLECTUAL PROPERTY ORGANIZATION
International Bureau



INTERNATIONAL APPLICATION PUBLISHED UNDER THE PATENT COOPERATION TREATY (PCT)

(51) International Patent Classification ⁶ : C07C 51/00	A2	(11) International Publication Number: WO 98/15517 (43) International Publication Date: 16 April 1998 (16.04.98)
(21) International Application Number: PCT/US97/15844 (22) International Filing Date: 2 October 1997 (02.10.97) (30) Priority Data: 119387 9 October 1996 (09.10.96) IS (71) Applicant (for all designated States except US): CARGILL INCORPORATED [US/US]; 15407 McGinty Road West, Wayzata, MN 55391-2399 (US). (72) Inventors; and (75) Inventors/Applicants (for US only): EYAL, Aharon, Meir [IL/IL]; Beitar Street 32, 93380 Jerusalem (IL). GRUBER, Patrick, R. [US/US]; 10951 Flanders Court, N.E., Blaine, MN 55449 (US). FISHER, Rod, R. [US/US]; 16820 South Shore Lane, Eden Prairie, MN 55346 (US). KOLSTAD, Jeffrey, J. [US/US]; 16122 Ringer Road, Wayzata, MN 55391 (US). (74) Agents: GALLOWAY, Peter, D.; Ladas & Parry, 26 West 61st street, New York, NY 10023 (US) et al.		(81) Designated States: AL, AM, AT, AU, AZ, BA, BB, BG, BR, BY, CA, CH, CN, CU, CZ, DE, DK, EE, ES, FI, GB, GE, GH, HU, ID, IS, JP, KE, KG, KP, KR, KZ, LC, LK, LR, LS, LT, LU, LV, MD, MG, MK, MN, MW, MX, NO, NZ, PL, PT, RO, RU, SD, SE, SG, SI, SK, SL, TJ, TM, TR, TT, UA, UG, US, UZ, VN, YU, ZW, ARIPO patent (GH, KE, LS, MW, SD, SZ, UG, ZW), Eurasian patent (AM, AZ, BY, KG, KZ, MD, RU, TJ, TM), European patent (AT, BE, CH, DE, DK, ES, FI, FR, GB, GR, IE, IT, LU, MC, NL, PT, SE), OAPI patent (BF, BJ, CF, CG, CI, CM, GA, GN, ML, MR, NE, SN, TD, TG). Published <i>Without international search report and to be republished upon receipt of that report.</i>
(54) Title: <u>PROCESS FOR THE RECOVERY OF LACTIC ACID</u> (57) Abstract <p>The invention provides a process for the recovery of lactic acid and products thereof from an aqueous solution containing free lactic acid and at least one lactate salt at a total concentration of at least 5 %, the process comprising the steps of: extracting at least 70 % of the free lactic acid from the aqueous solution by contacting the solution with a basic extractant, to form a lactic acid-containing extract and a lactic acid-depleted, lactate salt-containing aqueous solution; separating the lactic acid-containing extract from the depleted aqueous solution; and stripping the extracted lactic acid from the extract by methods known per se, to form a solution of lactic acid and a stripped extractant.</p>		

28 Rec'd PCT/PTO 08 APR 1999

FOR THE PURPOSES OF INFORMATION ONLY

Codes used to identify States party to the PCT on the front pages of pamphlets publishing international applications under the PCT.

AL	Albania	ES	Spain	LS	Lesotho	SI	Slovenia
AM	Armenia	FI	Finland	LT	Lithuania	SK	Slovakia
AT	Austria	FR	France	LU	Luxembourg	SN	Senegal
AU	Australia	GA	Gabon	LV	Latvia	SZ	Swaziland
AZ	Azerbaijan	GB	United Kingdom	MC	Monaco	TD	Chad
BA	Bosnia and Herzegovina	GE	Georgia	MD	Republic of Moldova	TG	Togo
BB	Barbados	GH	Ghana	MG	Madagascar	TJ	Tajikistan
BE	Belgium	GN	Guinea	MK	The former Yugoslav Republic of Macedonia	TM	Turkmenistan
BF	Burkina Faso	GR	Greece			TR	Turkey
BG	Bulgaria	HU	Hungary	ML	Mali	TT	Trinidad and Tobago
BJ	Benin	IE	Ireland	MN	Mongolia	UA	Ukraine
BR	Brazil	IL	Israel	MR	Mauritania	UG	Uganda
BY	Belarus	IS	Iceland	MW	Malawi	US	United States of America
CA	Canada	IT	Italy	MX	Mexico	UZ	Uzbekistan
CF	Central African Republic	JP	Japan	NE	Niger	VN	Viet Nam
CG	Congo	KE	Kenya	NL	Netherlands	YU	Yugoslavia
CH	Switzerland	KG	Kyrgyzstan	NO	Norway	ZW	Zimbabwe
CI	Côte d'Ivoire	KP	Democratic People's Republic of Korea	NZ	New Zealand		
CM	Cameroon			PL	Poland		
CN	China	KR	Republic of Korea	PT	Portugal		
CU	Cuba	KZ	Kazakhstan	RO	Romania		
CZ	Czech Republic	LC	Saint Lucia	RU	Russian Federation		
DE	Germany	LI	Licchtenstein	SD	Sudan		
DK	Denmark	LK	Sri Lanka	SE	Sweden		
EE	Estonia	LR	Liberia	SG	Singapore		

PROCESS FOR THE RECOVERY OF LACTIC ACID

The present invention relates to a process for the recovery of lactic acid. More particularly, the present invention relates to a process for the recovery of lactic acid and products thereof from an aqueous solution containing free lactic acid and at least one lactate salt.

Lactic acid has long been used as a food additive and in various chemical and pharmaceutical applications. More recently, lactic acid has been used in the making of biodegradable polylactic acid polymers as a replacement for present plastic materials, as well as for various new uses where biodegradability is needed or desired. Accordingly, there is an ever-increasing demand for lactic acid. The present invention aims at meeting this demand by providing an efficient and environmentally friendly process for producing lactic acid which avoids the consumption of bases and acids and substantially reduces, if not eliminates, the formation of waste or byproduct salts.

The production of lactic acid is commonly carried out by fermentation of a strain of the bacterial genus *Lactobacillus*, and, for example, more particularly by the species *Lactobacillus delbrueckii* or *Lactobacillus acidophilus*. In general, the production of lactic acid by fermentation in a fermentation broth is well-known in the art. The fermentation substrate consists of carbohydrates together with suitable mineral and proteinaceous nutrients. Because the lactic acid-producing microorganisms are inhibited in a strongly acidic environment, lactic acid fermentation is usually conducted at about neutral pH and a neutralizing agent is added for pH adjustment. As the pKa of lactic acid is 3.86, at the pH of fermentation, practically only lactate salts exist. Thus, recovery of lactic acid in an acid form from the fermentation

liquor requires chemical conversion. Several processes were developed for such conversion.

In some of the processes, the conversion liberates lactic acid in solution, e.g., by displacement with a strong acid. Thus, when calcium bases are used as the neutralizing agents in the fermentation, calcium lactate is formed. Reacting the calcium lactate-containing fermentation liquor with sulfuric acid results in precipitation of gypsum and liberation of lactic acid in the solution.

Nakanishi and Tsuda, in JP 46/30176, consider production of 1-butyl lactate by extraction of an acidified crude fermentation broth with 1-butanol, followed by esterification of the extract phase. BASF (EP 159 285) considers a similar process with isobutanol, to form isobutyl lactate. The process of WO 93/00440, assigned to DuPont, comprises the steps of: (1) simultaneously mixing a strong acid, an alcohol, and a concentrated fermentation broth which contains mainly basic salts of lactic acid, which react to form a crystal precipitate comprising basic salts of the strong acid and an impure lactate ester of the alcohol; (2) removing water from the mixture as a water/alcohol azeotrop, which can be accomplished either sequentially or substantially simultaneously with step (1); (3) removing the crystal precipitate from the mixture; and (4) distilling the impure lactate ester to remove impurities and recovering the high purity ester.

Alternatively to purifying the lactic acid, which is liberated by displacement with a strong acid through esterification and distillation of the ester, one could purify it by extraction. The extractant could be a relatively weak one, and would allow the recovery of the extracted HLa at a high concentration by back-extraction. The known, and food-approved, weak

extractants to be considered are amine-based or solvating extractants. One may consider esters, ethers, ketones, aldehydes, etc., but alkanols seem to be preferable.

Out of these two groups of weak extractants, the amine-based ones are more attractive, but they would not work in a simple process wherein the stronger than lactic displacing acid is added to the lactate salt-containing solution and the liberated HLa is directly extracted by contact with the extractant. The amine-based extractant prefers the stronger acid in a mixture, and would therefore reverse the reaction, removing the added acid.

Liquid-liquid extraction (LLE) proved to be an efficient way for recovering acidic fermentation products from fermentation liquors. Thus, a large fraction of the world's citric acid production uses an LLE process which recovers the acid from the broth by extraction with an extractant composed of a water-immiscible amine in a diluent. This extractant combines high recovery yields and high selectivity, resulting in a pure product and reversibility.

Baniel and co-inventors (U.S. Patent Application 4,275,234) have found that the extracted acid can be recovered from the acid-containing extract by back-extraction with water. They have also found that, if the back-extraction is conducted at a temperature higher than that of the extraction, the concentration of the acid in the back-extract (the aqueous product of the back-extraction) could be significantly higher than that in the broth. Thus, in addition to the recovery at high yield and purity, extraction by an amine-based extractant provides for concentration of the recovered product and thereby for saving in energy consumption. An amine-based extractant similar to the one used in the citric acid process would be suitable for extraction of free lactic acid.

Acidulating neutral fermentation liquors by the addition of acids usually results in the formation of by-product salts, such as the gypsum in the example used above. Reagents are consumed and disposal of undesired by-products is required. Efforts have recently been made to recover lactic acid from fermentation liquors without the formation of by-product salts; such processes will be referred to herein as "salt-splitting processes."

In some recently published patents, LLE is applied for salt-splitting. Thus, in U.S. Patent 5,132,456 (King), a strongly basic extractant extracts part of the lactic acid from the neutral solution, which results in a lactic acid-loaded extractant and a basic solution. This basic solution, which still contains most of the lactic acid values, could be recycled as a neutralizing medium to the fermentation. In U.S. Patent No. 5,510,526 (Baniel), the extraction of the acid is conducted under CO₂ pressure so that a bicarbonate is formed. The latter can be used as a neutralizing agent in the fermentation. In order to limit the CO₂ pressure to an economic one and still achieve high yields, the extractant used should be quite strong.

Recently, new strains have been developed for lactic acid fermentation which can operate at slightly acidic conditions. It is expected that the fermentation pH will be further lowered on future development, probably at the cost of lowering the overall concentration in the solution. As long as the pH of the broth is >5, practically all of the product is still in the salt form. However, at a lower pH, a fraction of the lactic acid in the broth is not neutralized. Thus, at pH of 4.8 and 3.8, about 10% and about 50%, respectively, could be considered as being in free acid form.

It would not be expected that free lactic acid could be extracted efficiently from the lactate salt-containing broth by an amine-based extractant, due to the buffering effect of the salt. Amines extract acids through ion-pair formation and should therefore be positively charged. In the case of primary, secondary and tertiary amines (quaternary ones are not suitable for reversible extraction), the formation of the required positive charge is by binding protons (protonation) from the aqueous solution. Extraction efficiency is therefore determined by the availability of protons in the aqueous solution. Thus, extraction of the free lactic acid is strongly dependent on the concentration of the lactate salts in the solution:

$$[H] = K_a[HLa]/[La]$$

where $[H]$, $[HLa]$ and $[La]$ denote the concentration of protons, undissociated lactic acid and lactate ions, respectively, and K_a is the dissociation constant of lactic acid. A significant lactate salt to free lactic acid ratio, or low free acid to salt ratio, substantially decreases the ratio $[HLa]/[La]$ and thereby decreases the availability of protons in the aqueous solution and the protonation of the amine. Therefore, the efficiency of extraction of the free lactic acid is expected to be low. It would be even lower, if the extractant already contains lactic acid from a previous stage.

Recovery of the free lactic acid from the fermentation liquor by LLE, if feasible, would still leave lactate values, i.e., lactic acid and lactate salts, in the aqueous solution. Recycling of those values back to the fermentation is feasible, but quite problematic and costly, for several reasons: (a) since a complete recycle would build up impurities in the system, a bleed would be required, and treatment of the bleed stream would be needed to avoid significant losses; (b) a separate operation may be needed for the removal of traces of extractant from the recycled stream; (c) there would probably be a

need to sterilize the recycle stream; and (d) water distillation from the recycled stream may be needed to maintain the water balance.

Alternatively, one can operate one of the salt-splitting processes for the recovery of lactic acid from the salts. If LLE processes are chosen, an extract loaded with lactic acid would be formed. Back-extraction of the lactic acid from this extract, as well as from the extract formed on the extraction of the free lactic acid, would be required. The lactic acid concentration in both extracts is expected to be low, due to the low activity of the lactic acid in the source from which it is extracted. That is particularly true for the salt-splitting process. The concentration of the lactic acid in the back-extract is therefore expected to be low.

U.S. Patent 5,132,456 suggests a way to recover extracted carboxylic acid from extracts formed on LLE-based salt-splitting. It comprises leaching or back-extraction with an aqueous solution of ammonia or low molecular weight alkyl amine, especially trimethyl amine (TMA). The resultant aqueous ammonium or alkylammonium carboxylate solution can be concentrated, if necessary, and the carboxylate can be decomposed thermally to yield the product carboxylic acid and ammonia or amine, which can be condensed and recycled. This process is costly and complex, and is particularly problematic for recovery of extracted lactic acid, as stated in said patent:

"For lactic acid, the decomposition is incomplete, being stopped by the formation of a viscous, almost glassy mass containing polymerized lactic acid along with substantial TMA and water. There are, however, effective ways of driving the decomposition to completion for lactic acid, such as diluting the viscous mass with an appropriate solvent (e.g., methyl isobutyl ketone) and continuing the heating and decomposition process."

With the above state of the art in mind, it has now been surprisingly found that a basic extractant is capable of extracting most of the free acid from a fermentation liquor, even if the free lactic acid to lactate salt ratio in it is lower than 1:3. Furthermore, high yield of extraction was found, even with an extractant that comprises lactic acid from a previous step.

Thus, according to the present invention, there is provided a process for the recovery of lactic acid and products thereof from an aqueous solution containing free lactic acid and at least one lactate salt at a total concentration of at least 5%, said process comprising the steps of: (a) extracting at least 70% of the free lactic acid from said aqueous solution by contacting said solution with a basic extractant, to form a lactic acid-containing extract and a lactic acid-depleted, lactate salt-containing aqueous solution; (b) separating said lactic acid-containing extract from said depleted aqueous solution; and (c) stripping the extracted lactic acid from said extract by methods known per se, to form a solution of lactic acid and a stripped extractant.

In a preferred embodiment of the present invention said process further comprises the step of (d) recovering lactic acid and products thereof from said lactate salt in said lactic acid-depleted aqueous solution by methods known per se.

Preferably said process is carried out on an aqueous solution containing free lactic acid and at least one lactate salt wherein the ratio between said free lactic acid and said lactate salt is between 1:9 and 5:1, and most preferably on an aqueous solution wherein the ratio between said free lactic acid and said lactate salt is between 1:9 and 3:1.

In an especially preferred embodiment of the present invention said basic extractant comprises a portion of lactic acid, preferably at least 3% lactic acid extracted in a previous step, and said solution is contacted with said extractant to form an extract comprising lactic acid in an amount greater than said portion and a lactic acid-depleted, lactate salt-containing aqueous solution. In especially preferred embodiments of the present invention the basic extractant used in step (a) comprises at least 5% lactic acid extracted in previous step.

Preferably said basic extractant in step (a) has a basicity corresponding to a pKa lower than 7 and in especially preferred embodiments of the present invention said basic extractant has a basicity corresponding to a pKa lower than 6.

In a further preferred embodiment of the invention, both the extraction of the free acid from the broth and the salt-splitting of the lactate salt left in the solution are conducted by LLE with a basic extractant. It is further preferred to use an extractant comprising amine for both, and even more preferred to use extractants comprising the same amine, so that the same extractant could be used, as is or after some adjustment, in both extractions.

In yet a further preferred embodiment of the invention, the process comprises the steps of: (a) extracting most of the free lactic acid from a fermentation liquor comprising the free acid and a lactate salt by an extractant recycled from a previous step; (b) stripping the lactic acid loaded extractant obtained, preferably by back-extraction with water, at a temperature higher than that of the extraction, to form purified lactic acid solution and a stripped extractant; and (c) using the stripped extractant to recover lactic acid from the lactate salt-containing, lactic acid-depleted aqueous solution formed in step

(a). The lactic acid-containing extractant formed in step (c) is suitable for extraction of free lactic acid from additional fermentation liquor, according to step (a).

The advantages of the process of the preferred embodiment of the invention include the following: (1) recovery of lactate values from the free acid fraction and salt-splitting are effected by LLE, which ensures high recovery yields, high purity, and relatively high product concentrations; (2) there is no need to operate two separate extraction cycles; (3) the stripped extractant, which has the strongest extraction power, is utilized where the strong extraction power is mostly needed, i.e., for the salt-splitting; (4) the surprising finding that even a partially loaded extractant is capable of efficient extraction of the free lactic acid in the presence of lactate salt is best utilized; and (5) an extract containing lactic acid from both the free lactic acid and the salt-splitting is fed to the stripping operation in an overall high concentration, so that the concentration of the back-extract is high. Such high concentrations of back-extract are not attainable by operating the salt-splitting separately and stripping at the same conditions. Neither can they be obtained by operating the salt-splitting and the recovery of the free acid in two separate cycles and mixing the extract for back-extraction, nor by back-extracting them separately and mixing the back-extracts.

The preferred amines for the extractant are chosen from the group consisting of primary, secondary and tertiary amines, with a total number of at least 18 carbon atoms. Mostly preferred are tertiary amines. A diluent is usually used to achieve the required physical properties.

The basicity of the extractant is easily adjusted by adding a polar solvent to the extractant. Such polar solvents enhance the extraction efficiency

of the amine, which is the main active component, and are usually referred to as "enhancers." Alkanols provide very efficient enhancers. The basicity of the extractant is thus adjusted by the amount of enhancer therein, or, more precisely, by the enhancer to amine molar ratio.

The basicity of water-soluble bases is easily determined by their degree of dissociation in aqueous solution. The basicity of water-immiscible extractants is determined indirectly, through their interaction with solutes in an aqueous solution. Thus, the apparent basicity of highly basic extractants can be compared by contacting them with aqueous solutions of NaCl and determining the pH of the aqueous solution in equilibrium. The higher the pH is, the stronger is the apparent basicity of the extractant. For comparing extractants of medium or weak basicity, equilibration with acid solutions is preferred. Unlike water-soluble bases, the apparent basicity found for water-immiscible extractants is determined, in addition to the properties of the amine, by the acid in the aqueous solution, by steric hindrance to extraction, and by the diluents of the amine.

While improving the extraction, the presence of an enhancer interferes in the back-extraction. The proportion of the enhancer in the solution should therefore be adjusted, to provide for high yields in the extraction and efficient back-extraction, resulting in lactic acid solutions of high concentration. It is also possible to remove at least a part of the enhancer prior to back-extraction.

As explained hereinabove, the basicity of the extractant used in the salt-splitting should be quite high. Extraction of the free acid, on the other hand, can be conducted with a weaker extractant. A process combining salt-splitting

with the recovery of the free acid could be operated in several ways, including the following:

1. Two separate extraction and back-extraction cycles can be operated.
2. Two extractions can be operated; the extracts are combined; at least part of the enhancer is removed; the resulting organic phase is back-extracted; the stripped organic phase is split into two streams; the enhancer content of each stream is adjusted to the required level, and each stream is used again in the separate extraction.
3. The extraction may be operated according to the above-described preferred process, where the stripped extractant is used first in the salt-splitting conducted on the lactic acid-depleted solution, and then for the extraction of the free lactic acid of a fresh solution.

It would have been expected that adjustment of the extractant composition would be needed in process 3 above, e.g., by adding enhancer to the extractant after stripping and prior to the salt-splitting operation, and removing some enhancer prior to the extraction of the free lactic acid. It was surprisingly found that such an adjustment is not necessary.

In preferred embodiments of the present invention, the stripped extractant formed in step (c) of the process is used as is, or after some adjustment, as the extractant in step (d), and the lactic acid-containing extractant formed in step (d) is used as is, or after some adjustment, as the extractant in step (a), wherein said adjustment comprises adding or removing a polar solvent.

While the invention will now be described in connection with certain preferred embodiments in the following examples so that aspects thereof may be more fully understood and appreciated, it is not intended to limit the

invention to these particular embodiments. On the contrary, it is intended to cover all alternatives, modifications and equivalents as may be included within the scope of the invention as defined by the appended claims. Thus, the following examples which include preferred embodiments will serve to illustrate the practice of this invention, it being understood that the particulars shown are by way of example and for purposes of illustrative discussion of preferred embodiments of the present invention only and are presented in the cause of providing what is believed to be the most useful and readily understood description of formulation procedures as well as of the principles and conceptual aspects of the invention.

EXAMPLES

Example 1

An extractant containing 48 wt% tricaprylyl amine (Henkel's Alamine 336), 30 wt% octanol and 22 wt% kerosene was prepared by mixing the components at the desired ratio. A starting aqueous solution was prepared by mixing solutions of sodium lactate and lactic acid so that their final concentrations were 2.9 and 1.5 mol/Kg respectively (lactic acid to sodium lactate molar ratio of 1:1.9).

The aqueous solution was equilibrated at ambient temperature with three successive portions of the organic phase. Each equilibration was at aqueous to organic wt ratio of 2:1. The phases were then separated and analyzed for their lactic acid content.

The results show that 83% of the lactic acid in the aqueous phase was extracted.

Example 2

An extractant containing 48 wt% tricaprylyl amine (Henkel's Alamine 336), 20 wt% octanol and 32 wt% kerosene was prepared by mixing the components at the desired ratio. A starting aqueous solution was prepared by mixing solutions of sodium lactate and lactic acid so that their final concentrations were 1.7 and 2.8 mol/Kg respectively (lactic acid to sodium lactate molar ratio of 1:0.61).

The aqueous solution was equilibrated at ambient temperature with a portion of the organic phase. The phases were then separated and analyzed for their lactic acid content. The resulting aqueous phase was equilibrated with another portion of the organic phase, separated and analyzed. These operations were repeated several times.

The equilibrium lactic acid concentrations (mol/Kg) in the successive contacts in the aqueous and organic phases, respectively, were:

- 1) 2.3 and 1.9;
- 2) 1.6 and 1.7;
- 3) 0.93 and 1.43;
- 4) 0.23 and 0.83; and
- 5) 0.05 and 0.28.

Example 3

The procedure of Example 2 was repeated, except that the starting composition of the aqueous phase was 1.6 mol/Kg lactic acid and 1.0 mol/Kg sodium lactate. The equilibrium lactic acid concentrations (mol/Kg) in the successive contacts in the aqueous and organic phases, respectively, were:

- 1) 1.1 and 1.56;
- 2) 0.61 and 1.3;
- 3) 0.29 and 0.98;

- 4) 0.11 and 0.53; and
- 5) 0.03 and 0.187.

Example 4

The procedure in Example 2 was repeated, except that the starting composition of the aqueous phase was 0.9 mol/Kg lactic acid and 0.4 mol/Kg sodium lactate. The equilibrium lactic acid concentrations (mol/Kg) in the successive contacts in the aqueous and organic phases, respectively, were:

- 1) 0.24 and 0.79;
- 2) 0.096 and 0.395; and
- 3) 0.028 and 0.185.

Example 5

The procedure in Example 2 was repeated, except that the starting composition of the aqueous phase was 0.71 mol/Kg lactic acid and 0.32 equ/Kg calcium lactate. The equilibrium lactic acid concentrations (mol/Kg) in the successive contacts in the aqueous and organic phases, respectively, were:

- 1) 0.37 and 1.16;
- 2) 0.14 and 0.33; and
- 3) 0.009 and 0.1.

The results in Examples 1 to 5 show that nearly all the free lactic acid can be extracted from solutions comprising it along with lactate salts. This is true for various starting concentrations and acid to salt molar ratios. The distribution coefficients were high.

Example 6

An aqueous solution containing 1.2 mol/Kg lactic acid and 1.5 mol/Kg sodium lactate was counter-currently extracted with an extractant composed of 48 wt% tricaprylyl amine (Henkel's Alamine 336), 30 wt% octanol and 22 wt% kerosene. The organic to aqueous phase ratio was 1:1 wt/wt. In four stages, the extraction of the free acid was nearly completed. The lactic acid concentration in the extract formed was 1.1 mol/Kg. The extract was counter-currently back-extracted with water at 140°C. The organic to aqueous ratio was 1:0.8 wt/wt. In six stages, most of the acid was back-extracted from the extractant to form an aqueous solution of 1.25 mol/Kg lactic acid.

Example 7

The experiment in Example 6 was repeated, except that the composition of the aqueous phase was 0.7 mol/Kg lactic acid and 0.32 equ/Kg calcium lactate. The organic to aqueous ratio in the extraction was 0.87:1. The loaded extractant contained 0.7 mol/Kg lactic acid. Back-extraction in conditions similar to those in Example 6 resulted in a 0.7 mol/Kg lactic acid solution.

Concentrated sulfuric acid solution was added dropwise to the aqueous solution resulting from the extraction step, in an amount equivalent to the calcium ion content. The precipitated gypsum was removed by decantation. The resulting aqueous solution was extracted with an extractant composed as above. Practically all the lactate values in the aqueous solution were extracted as lactic acid, which was then recovered from the organic phase by back-extraction.

Example 8

An aqueous starting solution containing 2.5 mol/Kg lactic acid and 2.5 mol/Kg sodium lactate was extracted with an extractant composed as in Example 1. Practically all the lactic acid was extracted. The remaining aqueous phase was concentrated to 5 mol/Kg sodium lactate and extracted by a fresh extractant of similar composition. In organic to aqueous wt/wt ratio of 7:1, under CO₂ pressure of 30 atmospheres, most of the lactate values were extracted as lactic acid in eight stages. The extract obtained, comprising about 0.7 mol/Kg lactic acid, was used to extract lactic acid from another portion of the starting aqueous solution containing lactic acid. At organic to aqueous ratio of 2:1 wt/wt and six stages, more than 80% of the acid was extracted. The lactic acid concentration in the obtained extract was 1.7 mol/Kg. Back-extraction at 150°C resulted in a 14% lactic acid solution.

It will be evident to those skilled in the art that the invention is not limited to the details of the foregoing illustrative examples and that the present invention may be embodied in other specific forms without departing from the essential attributes thereof, and it is therefore desired that the present embodiments and examples be considered in all respects as illustrative and not restrictive, reference being made to the appended claims, rather than to the foregoing description, and all changes which come within the meaning and range of equivalency of the claims are therefore intended to be embraced therein.

WHAT IS CLAIMED IS:

1. A process for the recovery of lactic acid and products thereof from an aqueous solution containing free lactic acid and at least one lactate salt at a total concentration of at least 5%, said process comprising the steps of:
 - (a) extracting at least 70% of the free lactic acid from said aqueous solution by contacting said solution with a basic extractant, to form a lactic acid-containing extract and a lactic acid-depleted, lactate salt-containing aqueous solution;
 - (b) separating said lactic acid-containing extract from said depleted aqueous solution; and
 - (c) stripping the extracted lactic acid from said extract by methods known per se, to form a solution of lactic acid and a stripped extractant.
2. A process according to claim 1, comprising the further step of:
 - (d) recovering lactic acid and products thereof from said lactate salt in said lactic acid-depleted aqueous solution by methods known per se.
3. A process according to claim 1, wherein the ratio between said free lactic acid and said lactate salt is between 1:9 and 5:1.
4. A process according to claim 1, wherein the ratio between said free lactic acid and said lactate salt is between 1:9 and 3:1.
5. A process according to claim 1, wherein said basic extractant comprises a portion of lactic acid and said solution is contacted with said extractant to form an extract comprising lactic acid in an amount greater than said portion and a lactic acid-depleted, lactate salt-containing aqueous solution.

6. A process according to claim 1, wherein the recovery of lactic acid from the lactate salt in said lactic acid-depleted aqueous solution comprises extraction with a basic extractant.
7. A process according to claim 6, wherein both the extractant used for the extraction of free lactic acid in step (a) and the extractant used for extraction of lactic acid from said lactic acid salt in step (d) comprise a water-immiscible amine.
8. A process according to claim 7, wherein the same water-immiscible amine is used in both of said two extractants.
9. A process according to claim 2, wherein said lactic acid-containing extractant formed in step (d) is used, as is or after some adjustment, as the extractant in step (a).
10. A process according to claim 2, wherein said stripped extractant formed in step (c) is used, as is or after some adjustment, as the extractant in step (d).
11. A process according to claim 9 or claim 10, wherein said adjustment comprises adding a polar solvent.
12. A process according to claim 9 or claim 10, wherein said adjustment comprises removing a polar solvent.
13. A process according to claim 1, wherein the ratio of free lactic acid to lactate salt is up to 2:1.

14. A process according to claim 1, wherein the basic extractant used in step (a) comprises at least 3% of the lactic acid extracted in a previous step.
15. A process according to claim 1, wherein said aqueous solution is concentrated by water evaporation prior to step (a).
16. A process according to claim 1, wherein said aqueous solution containing free lactic acid and lactate salt is a result of fermentation.
17. A process according to claim 1, wherein said lactate salt is selected from the group consisting of calcium lactate, sodium lactate and ammonium lactate.
18. A process according to claim 1, wherein said basic extractant in step (a) has a basicity corresponding to a pKa lower than 7.
19. A process according to claim 2, wherein:
 - said basic extractant in step (a) is recycled from a previous step;
 - said lactic acid-loaded extract obtained in step (a) is stripped to form a solution of purified lactic acid and said stripped extractant;
 - said stripped extractant obtained in step (c) is used for the recovery of lactic acid from said lactate salt in step (d); and
 - the lactic acid-comprising extract formed in step (d) is used for extraction of free lactic acid in step (a).
20. A process according to claim 1, wherein said recovery of lactic acid from said lactate salt in step (a) is effected under CO₂ pressure.

21. A process according to claim 1, wherein said recovery of lactic acid and products thereof from said lactate salt in said lactic acid-depleted aqueous solution is achieved by using an acid stronger than lactic acid.
22. A process according to claim 20, wherein said stronger acid is sulfuric acid, and a sulfate salt is formed as a by-product.
23. A process according to claim 1, wherein said recovery of lactic acid and products thereof from said lactate salt in said lactic acid-depleted aqueous solution is achieved through the use of electric energy.

From the
INTERNATIONAL PRELIMINARY EXAMINING AUTHORITY

PCT

NOTIFICATION OF TRANSMITTAL OF
THE INTERNATIONAL PRELIMINARY
EXAMINATION REPORT
(PCT Rule 71.1)

To:

GALLOWAY, Peter D.
Ladas & Parry
26 West 61st Street
New York, NY 10023
ETATS-UNIS D'AMERIQUE

23 Rec'd PCT/PTO 08 APR 1999

Date of mailing
(day/month/year)

08. 12. 98

Applicant's or agent's file reference
119,387

IMPORTANT NOTIFICATION

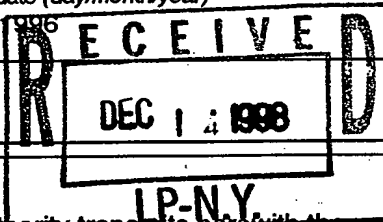
International application No.
PCT/US97/15844

International filing date (day/month/year)
02/10/1997

Priority date (day/month/year)
09/10/1996

Applicant

CARGILL INCORPORATED et al.



- The applicant is hereby notified that this International Preliminary Examining Authority transmits herewith the international preliminary examination report and its annexes, if any, established on the international application.
- A copy of the report and its annexes, if any, is being transmitted to the International Bureau for communication to all the elected Offices.
- Where required by any of the elected Offices, the International Bureau will prepare an English translation of the report (but not of any annexes) and will transmit such translation to those Offices.

4. REMINDER

The applicant must enter the national phase before each elected Office by performing certain acts (filing translations and paying national fees) within 30 months from the priority date (or later in some Offices) (Article 39(1)) (see also the reminder sent by the International Bureau with Form PCT/IB/301).

Where a translation of the international application must be furnished to an elected Office, that translation must contain a translation of any annexes to the international preliminary examination report. It is the applicant's responsibility to prepare and furnish such translation directly to each elected Office concerned.

For further details on the applicable time limits and requirements of the elected Offices, see Volume II of the PCT Applicant's Guide.

Name and mailing address of the IPEA/



European Patent Office
D-80298 Munich
Tel. (+49-89) 2399-0, Tx: 523656 epmu d
Fax: (+49-89) 2399-4465

Authorized officer

Roche, S

EMERGENCY
361100
Tel. (+49-89) 2399-8031



15. MAY

28289

11/8/99

PATENT COOPERATION TREATY

PCT

INTERNATIONAL PRELIMINARY EXAMINATION REPORT

(PCT Article 36 and Rule 70)

Applicant's or agent's file reference 119,387	FOR FURTHER ACTION See Notification of Transmittal of International Preliminary Examination Report (PCT/IPEA/416)	
International application No. PCT/US97/15844	International filing date (day/month/year) 02/10/1997	Priority date (day/month/year) 09/10/1996
International Patent Classification (IPC) or national classification and IPC C07C51/47		
Applicant CARGILL INCORPORATED et al.		

1. This international preliminary examination report has been prepared by this International Preliminary Examining Authority and is transmitted to the applicant according to Article 36.



2. This REPORT consists of a total of 5 sheets, including this cover sheet.

☒ This report is also accompanied by ANNEXES, i.e., sheets of the description, claims and/or drawings which have been amended and are the basis for this report and/or sheets containing rectifications made before this Authority (see Rule 70.16 and Section 607 of the Administrative Instructions under the PCT).

These annexes consist of a total of 4 sheets.

3. This report contains indications relating to the following items:

- I ☒ Basis of the report
- II ☐ Priority
- III ☒ Non-establishment of opinion with regard to novelty, inventive step and industrial applicability
- IV ☐ Lack of unity of invention
- V ☒ Reasoned statement under Article 35(2) with regard to novelty, inventive step or industrial applicability; citations and explanations supporting such statement
- VI ☐ Certain documents cited
- VII ☐ Certain defects in the international application
- VIII ☒ Certain observations on the international application

Date of submission of the demand 07/05/1998	Date of completion of this report 08.12.98
Name and mailing address of the IPEA/  European Patent Office D-80298 Munich Tel. (+49-89) 2399-0, Tx: 523656 pmu d Fax: (+49-89) 2399-4465	Authorized officer Jardon Alvarez, J Telephone No. (+49-89) 2399-8325 

INTERNATIONAL PRELIMINARY EXAMINATION REPORT

International application No. PCT/US97/15844

I. Basis of the report

1. This report has been drawn on the basis of (*substitute sheets which have been furnished to the receiving Office in response to an invitation under Article 14 are referred to in this report as "originally filed" and are not annexed to the report since they do not contain amendments.*):

Description, pages:

1,3-17	as originally filed			
2	as received on	05/11/1998	with letter of	03/11/1998

Claims, No.:

1-18	as received on	05/11/1998	with letter of	03/11/1998
------	----------------	------------	----------------	------------

2. The amendments have resulted in the cancellation of:

- ☐ the description, pages:
- ☐ the claims, Nos.:
- ☐ the drawings, sheets:

3. ☐ This report has been established as if (some of) the amendments had not been made, since they have been considered to go beyond the disclosure as filed (Rule 70.2(c)):

4. Additional observations, if necessary:

see separate sheet

III. Non-establishment of opinion with regard to novelty, inventive step and industrial applicability

The questions whether the claimed invention appears to be novel, to involve an inventive step (to be non-obvious), or to be industrially applicable have not been examined in respect of:

- ☐ the entire international application.
- ☒ claims Nos. 5,6.

b cause:

- ☐ the said international application, or the said claims Nos. relate to the following subject matter which does

**INTERNATIONAL PRELIMINARY
EXAMINATION REPORT**

International application No. PCT/US97/15844

not require an international preliminary examination (*specify*):

- ☒ the description, claims or drawings (*indicate particular elements below*) or said claims Nos. 5,6 are so unclear that no meaningful opinion could be formed (*specify*):

see separate sheet

- ☐ the claims, or said claims Nos. are so inadequately supported by the description that no meaningful opinion could be formed.
- ☐ no international search report has been established for the said claims Nos. .

V. Reasoned statement under Article 35(2) with regard to novelty, inventive step or industrial applicability; citations and explanations supporting such statement

1. Statement

Novelty (N)	Yes: Claims 1-4, 7-18
	No: Claims
Inventive step (IS)	Yes: Claims 1-4, 7-18
	No: Claims
Industrial applicability (IA)	Yes: Claims 1-4, 7-18
	No: Claims

2. Citations and explanations

see separate sheet

VIII. Certain observations on the international application

The following observations on the clarity of the claims, description, and drawings or on the question whether the claims are fully supported by the description, are made:

see separate sheet

Re Item I

Basis of the report

1. In step (a) of claim 1 some words are missing. It should read:
"(a) extracting at least 70 % of the free acid from said aqueous solution by contacting said **solution with a basis extractant, to form a lactic acid-containing extract and a lactic acid-depleted, lactate salt-containing aqueous solution**". (cf. page 7, second paragraph).

Re Item III

Non-establishment of opinion with regard to novelty, inventive step and industrial applicability

1. In claims 5 and 6 reference is made to certain "adjustment" in the process of claim 1. However no such adjustment is mentioned in claim 1. The subject-matter of claims 5 and 6 is therefore not clear.

Re Item V

Reasoned statement under Article 35(2) with regard to novelty, inventive step r industrial applicability; citations and explanations supporting such statement

1. None of the documents cited in the Search Report discloses a process for the recovery of lactic acid and products thereof from an aqueous solution containing free lactic acid and one lactate salt by extraction with a basic lactic acid-containing extractant, wherein the extractant is used first as basic extractant on the lactic acid-depleted aqueous solution (see step (d)) and then for the extraction of the free lactic acid of a fresh solution (see step e)) as described in independent claims 1 and 18.

Accordingly the subject-matter of claims 1 - 4 and 7 - 18 is novel (Art. 33(2) PCT).

2. The subject-matter of the claims 1 - 4 and 7 - 18 is also based on an inventive step (Art. 33(3) PCT).

As acknowledged at pages 1 to 6 of the present description, processes for the

**INTERNATIONAL PRELIMINARY
EXAMINATION REPORT - SEPARATE SHEET**

International application No. PCT/US97/15844

recovery of lactic acid from a fermentation liquor by extraction are already known (see US - 5 132 456, D1, claims and US - 5 510 526, D2, claims). In said known processes the starting material is essentially a lactate salt (see D1, col. 3, lines 66 - 67 and D2, col. 5, line 55 - col. 6, line 32 and examples).

The problem to be solved by the present application with respect to said prior art is to provide a further process for the recovery of lactic acid using as starting material an aqueous solution containing free lactic acid and a lactate salt. This problem is solved by the process according to claims 1 and 18 which allows a recovery of at least 70 % of the free acid (see examples).

There is no hint in the cited documents which would suggest that free lactic acid in the presence of the lactate salt could be extracted using a partially loaded extractant as in the present process. For further advantages of the process see page 9 of the description.

Re Item VIII

Certain observations on the international application

1. Claim 18 that relates to a particular embodiment of the process according to claim 1 should have been appropriately formulated as a claim dependent on claim 1 (Rule 6.4 PCT).
2. The description is not in conformity with the claims as required by Rule 5.1(a)(iii) PCT.

1. A process for the recovery of lactic acid and products thereof from an aqueous solution containing free lactic acid and at least one lactate salt at a total concentration of at least 5%, said process comprising the steps of:
 - (a) extracting at least 70% of the free acid from said aqueous solution by contacting said acid-depleted, lactate salt-containing aqueous solution;
 - (b) separating said lactic acid-containing extract from said depleted aqueous solution;
 - (c) stripping said extracted lactic acid from said extract by methods known per se, to form a solution of lactic acid and stripped basic extractant;
 - (d) recovering lactic acid and products thereof from said lactate salt in said lactic acid-depleted aqueous solution by a method comprising extraction with a basic extractant, substantially as obtained in step (c), to form lactic acid containing extractant; and
 - (e) using said lactic acid-containing extractant from step (d), substantially as is, as said basic extractant in step (a).
2. A process according to claim 1, wherein the ratio between said free lactic acid and said lactate salt is between 1:9 and 5:1.
3. A process according to claim 1, wherein the ratio between said free lactic acid and said lactate salt is between 1:9 and 3:1.
4. A process according to claim 1, wherein said basic extractant comprises a portion of lactic acid and said solution is contacted with said extractant to form an extract comprising lactic acid in an amount greater than said portion and a lactic acid-depleted, lactate salt-containing aqueous solution.
5. A process according to claim 1, wherein said adjustment comprises adding a polar solvent.
6. A process according to claim 1, wherein said adjustment comprises removing a polar solvent.
7. A process according to claim 1, wherein the ratio of free lactic acid to lactate salt is up to 2:1.
8. A process according to claim 1, wherein the basic extractant used in step (a) comprises at least 3% of the lactic acid extracted in a previous step.
9. A process according to claim 1, wherein said aqueous solution is concentrated by water evaporation prior to step (a).

10. A process according to claim 1, wherein said aqueous solution containing free lactic acid and lactate salt is a result of fermentation.
11. A process according to claim 1, wherein said lactate salt is selected from the group consisting of calcium lactate, sodium lactate and ammonium lactate.
12. A process according to claim 1, wherein said basic extractant in step (a) has a basicity corresponding to pKa lower than 7.
13. A process according to claim 1, wherein:
 - said basic extractant in step (a) is recycled from a previous step;
 - said lactic acid-loaded extract obtained in step (a) is stripped to form a solution of purified lactic acid and said stripped extractant;
 - said stripped extractant obtained in step (c) is used for the recovery of lactic acid from said lactate salt in step (d); and
 - the lactic acid-comprising extract formed in step (d) is used for extraction of free lactic acid in step (a).
14. A process according to claim 1, wherein said recovery of lactic acid from said lactate salt in step (a) is effected under CO₂ pressure.
15. A process according to claim 1, wherein said recovery of lactic acid and products thereof from said lactate salt in said lactic acid-depleted aqueous solution is achieved by using an acid stronger than lactic acid.
16. A process according to claim 14, wherein said stronger acid is sulfuric acid, and a sulfate salt is formed as a by-product.
17. A process according to claim 1, wherein said recovery of lactic acid and products thereof from said lactate salt in said lactic acid-depleted aqueous solution is achieved through the use of electric energy.
18. A process for the recovery of lactic acid and products thereof from an aqueous solution containing free lactic acid and at least one lactate salt at a total concentration of at least 5%, said process comprising the steps of:
 - (a) extracting at least 70% of the free acid from said aqueous solution by contacting said acid-depleted, lactate salt-containing aqueous solution;
 - (b) separating said lactic acid-containing extract from said depleted aqueous solution;
 - (c) stripping said extracted lactic acid from said extract by methods known per se, to form a solution of lactic acid and stripped basic extractant;

(d) recovering lactic acid and products thereof from said lactate salt in a portion of said lactic acid-depleted aqueous solution by a method comprising extraction with a basic extractant, substantially as obtained in step (c), to form lactic acid containing extractant; and

(e) using said lactic acid-containing extractant from step (d), substantially as is, as said basic extractant in step (a).

liquor requires chemical conversion. Several processes were developed for such conversion.

In some of the processes, the conversion liberates lactic acid in solution, e.g., by displacement with a strong acid. Thus, when calcium bases are used as the neutralizing agents in the fermentation, calcium lactate is formed. Reacting the calcium lactate-containing fermentation liquor with sulfuric acid results in precipitation of gypsum and liberation of lactic acid in the solution.

Nakanishi and Tsuda, in JP 46/30176, consider production of 1-butyl lactate by extraction of an acidified crude fermentation broth with 1-butanol, followed by esterification of the extract phase. BASF (EP-0 159 585) considers a similar process with isobutanol, to form isobutyl lactate. The process of WO 93/00440, assigned to DuPont, comprises the steps of: (1) simultaneously mixing a strong acid, an alcohol, and a concentrated fermentation broth which contains mainly basic salts of lactic acid, which react to form a crystal precipitate comprising basic salts of the strong acid and an impure lactate ester of the alcohol; (2) removing water from the mixture as a water/alcohol azeotrop, which can be accomplished either sequentially or substantially simultaneously with step (1); (3) removing the crystal precipitate from the mixture; and (4) distilling the impure lactate ester to remove impurities and recovering the high purity ester.

Alternatively to purifying the lactic acid, which is liberated by displacement with a strong acid through esterification and distillation of the ester, one could purify it by extraction. The extractant could be a relatively weak one, and would allow the recovery of the extracted HLa at a high concentration by back-extraction. The known, and food-approved, weak

PATENT COOPERATION TREATY

From the
INTERNATIONAL PRELIMINARY EXAMINING AUTHORITY

PCT

To:

GALLOWAY, Peter D.
Ladas & Parry
26 West 61st Street
New York, NY 10023
ETATS-UNIS D'AMERIQUE

NOTIFICATION OF RECEIPT OF DEMAND

(PCT Rule 61.1(b), first sentence
and Administrative Instructions, Section 601)

28 Rec'd PCT/PTO 08 APR 1999

Date of mailing
(day/month/year)

1 8. 05. 98

Applicant's or agent's file reference

119,387

IMPORTANT NOTIFICATION

International application No.

PCT/US 97/ 15844

International filing date (day/month/year)

02/10/1997

Priority date (day/month/year)

09/10/1996

Applicant

CARGILL INCORPORATED et al.

1. The applicant is hereby notified that this International Preliminary Examining Authority considers the following date as the date of receipt of the demand for international preliminary examination of the international application:

07/05/1998

2. This date of receipt is:

- ☒ the actual date of receipt of the demand.
☐ the date on which the proper corrections to the demand were timely received.

3. ☐ This date is **AFTER** the expiration of 19 months from the priority date.

Attention: The election(s) made in the demand does (do) not have the effect of postponing the commencement of the national phase until 30 months from the priority date (or later in some Offices)(Article 39(1)). Therefore, the acts for entry into the national phase must be performed within 20 months from the priority date (or later in some Offices) (Article 22).

For details, see Annex B to Form PCT/IB/301 sent by the International Bureau and Volume II of the PCT Applicant's Guide.

- ☐ This notification confirms the information given in person or by telephone on:

4. Only where paragraph 3 applies, a copy of this notification has been sent to the International Bureau.

Name and mailing address of the IPEA/



European Patent Office
D-80298 Munich
Tel. (+ 49-89) 2399-0, Tx: 523656 epmu d
Fax: (+ 49-89) 2399-4465

Authorized officer

Francis H. CHAVONAND

Telephone No.

PATENT COOPERATION TREATY

From the
INTERNATIONAL PRELIMINARY EXAMINING AUTHORITY

To:

GALLOWAY, Peter D.
Ladas & Parry
26 West 61st Street
New York, NY 10023
ETATS-UNIS D'AMERIQUE

PCT

WRITTEN OPINION

(PCT Rule 66)

Applicant's or agent's file reference
119,387

Date of mailing
(day/month/year)

07.07.98

REPLY DUE

within **3 month(s)**
from the above date of mailing

International application no.
PCT/US97/15844

International filing date (day/month/year)
02/10/1997

Priority date (day/month/year)
09/10/1996

International Patent Classification (IPC) or both national classification and IPC
C07C51/47

Applicant

CARGILL INCORPORATED et al.

1. This written opinion is the **first** drawn up by this International Preliminary Examining Authority.

2. This report contains indications relating to the following items:

- I ☒ Basis of the opinion
- II ☐ Priority
- III ☐ Non-establishment of opinion with regard to novelty, inventive step and industrial applicability
- IV ☐ Lack of unity of invention
- V ☒ Reasoned statement under Rule 66.2(a)(ii) with regard to novelty, inventive step or industrial applicability; citations and explanations supporting such statement
- VI ☐ Certain documents cited
- VII ☒ Certain defects in the international application
- VIII ☐ Certain observations on the international application

3. The applicant is hereby **invited to reply** to this opinion.

When? See the time limit indicated above. The applicant may, before the expiration of that time limit, request this Authority to grant an extension, see Rule 66.2(d).

How? By submitting a written reply, accompanied, where appropriate, by amendments, according to Rule 66.3. For the form and the language of the amendments, see Rules 66.8 and 66.9.

Also: For an additional opportunity to submit amendments, see Rule 66.4.
For the examiner's obligation to consider amendments and / or arguments, see Rule 66.4bis.
For an informal communication with the examiner, see Rule 66.6.

If no reply is filed, the international preliminary examination report will be established on the basis of this opinion.

4. The final date by which the international preliminary examination report must be established according to Rule 69.2 is: **09/02/1999**

Name and mailing address of the international preliminary examining authority



European Patent Office
D-80298 Munich
Tel. (+49-89) 2399-0, Tx: 523656 epmu d
Fax: (+49-89) 2399-4465

Authorized officer / Examiner
Jardon Alvarez, J

Formalities officer (incl. extension of time limits)

ENTERED BY
Rochas
CENTRAL
Telephone (+49-89) 2399-8031

ENTRY

10.11.98



10/11/98 24782 8/7/98

I. Basis of the opinion

1. This opinion has been drawn on the basis of (*substitute sheets which have been furnished to the receiving Office in response to an invitation under Article 14 are referred to in this opinion as "originally filed".*):

Description, pages:

1-17 as originally filed

Claims, No.:

1-23 as originally filed

2. The amendments have resulted in the cancellation of:

- ☐ the description, pages:
☐ the claims, Nos.:
☐ the drawings, sheets:

3. This opinion has been established as if (some of) the amendments had not been made, since they have been considered to go beyond the disclosure as filed (Rule 70.2(c)):

4. Additional observations, if necessary:

V. Reasoned statement under Rule 66.2(a)(ii) with regard to novelty, inventive step or industrial applicability; citations and explanations supporting such statement**1. Statement**

Novelty (N)	Claims	1-23
Inventive step (IS)	Claims	1-23
Industrial applicability (IA)	Claims	

2. Citations and explanations

see separate sheet

VII. Certain defects in the international application

The following defects in the form or contents of the international application have been noted:

see separate sheet

Re Item V

1. US - 5 132 456 (D1) discloses a process for recovering carboxylic acid from a carboxylic acid-containing aqueous feedstream having a pH close to or above the pK_a of the acid comprising contacting the feed with an extractant, separating the phases and recovering the acid by back-extraction (see claims 1 and 12). Examples 12 - 14 show the extraction of lactic acid at pH above and below the pK_a of the acid. The use of such pH implies that the starting solution contains free lactic acid and the lactate salt.

Accordingly this disclosure is considered to anticipate the subject-matter of claim 1 of the present application which is therefore not novel (Art. 33(2) PCT).

2. Dependent claims 2 to 23 do not appear to contain any features which, in combination with the features of any claim to which they refer, meet the requirements of the PCT in respect of novelty and/or inventive step. These claims relate to specific reaction conditions and/or to the use of specific extractants such as amines which are already known in the field, these features can be determined by the skilled person through routine experimentation.

Re Item VII

1. The EP- citation on the second full paragraph of page 2 appears to be wrong and should be checked. It should probably read EP - 0 159 585